2001 International Microprocesses & Nanotechnology Conference (MNC 2001)
October 30 –November 2, 2001
Matsue Kunibiki Messe, Matsue, Japan

Dynamics of mass-limited laser plasma targets as sources for EUVL

M. Richardson, C. Keyser, M. Al-Rabban*, & R. Bernath
Laser Plasma Laboratory,
School of Optics & CREOL, University of Central Florida,
4000 Central Florida Blvd, Orlando, FL 32816-2700, USA.
Tel:407 823 6819 Fax 407 823 3570 email:mcr@creol.ucf.edu

Abstract

Laser plasma sources are now considered as leading-candidate 13 nm EUV light sources for the next generation of advanced lithographic steppers. Configured with mass-limited targets, as a liquid jet or stream of droplets, or a gas jet of clustered molecules, this source has demonstrated levels of repeatability, lifetime and debris-free operation approaching those needed for engineering test lithography facilities. We have for many years been developing the liquid droplet laser plasma source. A high repetition-rate laser is fired at a continuous stream (100 kHz) of microscopic liquid droplets, whose mass, ideally, is that of the minimum number of atoms required to produce a fully ionized plasma having the optimum level of ionization for maximum radiation emission at 13 nm. Efficient conversion of laser light to this radiation can be accomplished by accessing Li-like Oxygen line emission at 13.5 nm using droplets of water. We have previously demonstrated high conversion efficiency with this target, and detailed investigations of the long-term effects of the ion sputtering of the multilayer mirrors integral to the light source.

In this paper we report a detailed experimental and theoretical study of the plasma and radiation dynamics of these droplet targets. For the first time the interaction region is investigated using separate optical probing techniques, revealing the symmetry and temporal evolution of the plasma expansion. This is compared with the predictions of hydrodynamic code calculations of the evolution of the electron density and temperature profiles. Details of the ionization state of the plasma is investigated spectroscopically, using a high-resolution flat field spectrograph and a new transmission grating spectrograph. Correspondence of the line emission with predicted line intensities from an atomic physics code is made to acquire a detailed understanding of the ionization dynamics in the plasma. These advances can now be extended to other laser interaction conditions with limited mass targets. This could lead to the development of a laser-plasma sources that are even more effective than current sources.

* Physics Dept, Qatar University, Doha, Qatar.